

SEQUENCE LISTING



<110> Rebecca E. Cahoon
Steven Gutteridge
Leslie T. Harvell
J. Antoni Rafalski
Yong Tao
Zude Weng

<120> Polynucleotides Encoding Aminolevulinic Acid Biosynthetic Enzymes

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<150> 60/146600

<151> 1999-07-30

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Val Ile Gly Leu Ser Val His Thr Ala Pro Val Glu Met Xaa Xaa Lys
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Leu Ala Val Ala Glu Glu Leu Trp Pro Arg Ala Ile Gln Glu Leu
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Gly Gly Gly Arg Arg Arg Ser Gly Val Val Arg Cys Asp Ala Ala Gly
  35             40             45

Val Glu Ala Gln Ala Gln Ala Val Ala Lys Ala Ala Ser Val Ala Ala
  50             55             60

Leu Glu Gln Phe Lys Ile Ser Ala Asp Arg Tyr Met Lys Glu Arg Ser
  65             70             75             80

Thr Ile Ala Val Ile Gly Leu Ser Val His Thr Ala Pro Val Glu Met
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Arg Glu Lys Leu Ala Val Ala Glu Glu Leu Trp Pro Arg Ala Ile Gln
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Glu Leu Thr Ser Leu Asn His Ile Glu Glu Ala Ala Val Leu Ser Thr
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Cys Asn Arg Met Glu Ile Tyr Val Val Ala Leu Ser Trp Asn Arg Gly
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Ile Arg Glu Val Val Asp Trp Met Ser Lys Lys Ser Gly Ile Pro Ala
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Ser Glu Leu Arg Glu His Leu Phe Ile Leu Arg Ser Ser Asp Ala Thr
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Arg His Leu Phe Glu Val Ser Ala Gly Leu Asp Ser Leu Val Leu Gly
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Asn Ser Gly Gly Leu Gly Lys Asn Ile Asp Arg Met Phe Lys Asp Ala

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              20              25              30
Val Ile Gly Leu Ser Val His Thr Ala Pro Val Glu Met Arg Glu Lys
              35              40              45
Leu Ala Val Ala Glu Glu Leu Trp Pro Arg Ala Ile Ser Glu Leu Thr
              50              55              60
Ser Leu Asn His Ile Glu Glu Val Ala Val Leu Xaa Leu Ser Thr Cys
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Val Ile Gly Leu Ser Val His Thr Ala Pro Val Glu Met Arg Glu Lys
      35             40             45

Leu Ala Val Ala Glu Glu Leu Trp Pro Arg Ala Ile Ser Glu Leu Thr
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Ser Leu Asn His Ile Glu Glu Ala Ala Val Leu Ser Thr Cys Asn Arg
      65             70             75             80

Met Glu Ile Tyr Val Val Ala Leu Ser Trp Asn Arg Gly Ile Arg Glu
      85             90             95

Val Val Asp Trp Met Ser Lys Lys Ser Gly Ile Pro Ala Ser Glu Leu
      100            105            110

Arg Glu His Leu Phe Met Leu Arg Asp Ser Asp Ala Thr Arg His Leu
      115            120            125

Phe Glu Val Ser Ala Gly Leu Asp Ser Leu Val Leu Gly Glu Gly Gln
      130            135            140

Ile Leu Ala Gln Val Lys Gln Val Val Arg Ser Gly Gln Asn Ser Gly
      145            150            155            160

Gly Leu Gly Lys Asn Ile Asp Arg Met Phe Lys Asp Ala Ile Thr Ala
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Gly Lys Arg Val Arg Cys Glu Thr Asn Ile Ser Ser Gly Ala Val Ser
      180            185            190

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Glu Cys Leu Ser Ala Arg Met Leu Leu Ile Gly Ala Gly Lys Met Gly
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 accgccttca aggtcatcat tcaccacttt tcccggncaa aacagaagaa ccctcattca 240
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Leu Lys Cys Ser Ser Ser Ser Ser Ser
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11
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 DNA
 Glycine max

The first of the steps with which we begin is to determine the nature of the problem. This is done by asking a series of questions which are designed to elicit information about the problem. The second step is to determine the objectives of the study. This is done by asking a series of questions which are designed to elicit information about the objectives of the study. The third step is to determine the scope of the study. This is done by asking a series of questions which are designed to elicit information about the scope of the study. The fourth step is to determine the methods of the study. This is done by asking a series of questions which are designed to elicit information about the methods of the study. The fifth step is to determine the results of the study. This is done by asking a series of questions which are designed to elicit information about the results of the study. The sixth step is to determine the conclusions of the study. This is done by asking a series of questions which are designed to elicit information about the conclusions of the study.

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Ile	Val	Asn	Lys	Leu	Leu	His	Gly	Pro	Met	Gln	His	Leu	Arg	Cys	Asp
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Gly	Asn	Asp	Ser	Arg	Thr	Leu	Ser	Glu	Thr	Leu	Glu	Asn	Met	Asn	Ala
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Met Lys Leu Pro Asp Ser Ser Phe Ala Asp Ser Gly Val Leu Val Val
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Gly Cys Arg Arg Met Val Val Val Asn Arg Thr Glu Glu Lys Val Asn

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Ala Ile Arg Lys	Glu Leu Lys Asp Val	Glu Ile Val Phe Arg Pro Phe				
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Ser Asp Met Leu	Ala Cys Ala Ala	Glu Ala Asp Val Ile Phe Thr Ser				
	260	265			270	
Thr Ala Ser Glu	Ser Pro Leu Phe	Ser Lys Gln Asn Val Gln Met Leu				
	275	280			285	
Pro Leu Val Asn His	Gly Arg Arg Arg	Leu Phe Val Asp Ile Ser Ile				
	290	295			300	
Pro Arg Asn Val Glu	Pro Gly Val Ser Asp	Leu Glu Thr Ala Leu Val				
	305	310			315	320
Tyr Asn Val Asp	Asp Leu Lys Glu Val	Val Ala Ala Asn Lys Glu Asp				
	325	330			335	
Arg Leu Gln Lys	Ala Glu Glu Ala Arg	Gly Ile Ile Leu Glu Glu Leu				
	340	345			350	
Asn Lys Phe Glu	Ala Trp Lys Asp	Ser Leu Glu Thr Val Pro Thr Ile				
	355	360			365	
Lys Lys Phe Arg	Ala Tyr Val Glu Arg	Ile Arg Ala Ser Glu Met Glu				
	370	375			380	
Lys Cys Leu Ser	Lys Met Gly Pro Asp	Val Ser Lys Gln Gln Lys Asp				
	385	390			395	400
Ala Ile Tyr Ala	Leu Ser Met Gly Ile	Val Asn Lys Leu Leu His Gly				
	405	410			415	
Pro Met Gln His	Leu Arg Cys Asp	Gly Lys Asn Asp Ser Ser Leu Ser				
	420	425			430	
Glu Val Leu Glu	Asn Met Arg Ala	Leu Asn Arg Met Tyr Asp Leu Glu				
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Thr Glu Ile Ser	Leu Ile Glu Glu Lys	Ile Arg Val Lys Met Glu Arg				
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Val Gln Lys						
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ttctccggtg cacaaattgg aggtctctatt gctcaaattgt ncttcctcct ctctcctcacc 120
accgccttca aggtcatcat tcaccacttt tcccggccaa aacagaagaa ccctcattca 180
gagaggggtt attcgctgcg acgctcagcc ctctgatgca tcatctgttg cnccaaataa 240
tgccaccgct ctctccgctc ttgagcagct caagacttct gcagctgata gatatacnaa 300
tgaaagcagc agnattaccg ccattgggggt cagtgtgcaa ctgcactgng aaatccgtgn 360
aaacttgcaa tcaggannag aatngccnga nntattnaan agtgtgngtn tgatatttaa 420
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Leu Leu Lys Cys Xaa Ser Ser Ser Ser Ser
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 cagtctgaat catatcgaag aggctgctgt tctgagtacc tgcaacagaa tggaaatata 180
 tgtgtgtggct ttatcgtgga accgtggtat tagagaagta gtagactgga tgtcaaagaa 240
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 <213> Triticum aestivum

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 35 40 45
 Leu Ser Thr Cys Asn Arg Met Glu Ile Tyr Val Val Ala Leu Ser Trp
 50 55 60
 Asn Arg Gly Ile Arg Glu Val Val Asp Trp Met Ser Lys Lys Ser Gly
 65 70 75 80
 Ile Pro Ala Ser Glu Leu Arg Glu His Leu Phe Met Leu Arg Asp Ser
 85 90 95
 Asp Ala Thr Arg His Leu Phe Glu Val Ser Ala Gly Leu Asp Ser Leu
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445

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Arg Pro Ala Ala Pro Arg Arg Ala Ser Ala Gly Arg Arg Ala Arg Leu
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Ser Val Val Arg Ala Ala Ile Ser Leu Glu Lys Gly Glu Lys Ala Tyr
      35          40          45
Thr Val Gln Lys Ser Glu Glu Ile Phe Asn Ala Ala Lys Glu Leu Met
      50          55          60
Pro Gly Gly Val Asn Ser Pro Val Arg Ala Phe Lys Ser Val Gly Gly
  65          70          75          80
Gln Pro Val Val Phe Asp Ser Val Lys Gly Ser Arg Met Trp Asp Val
          85          90          95
Asp Gly Asn Glu Tyr Ile Asp Tyr Val Gly Ser Trp Gly Pro Ala Ile
      100          105          110
Ile Gly His Ala Asp Asp Lys Val Asn Ala Ala Leu Ile Glu Thr Leu
      115          120          125
Lys Lys Gly Thr Ser Phe Gly Ala Pro Cys Leu Leu Glu Asn Val Leu
      130          135          140

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Ala Glu Met Val Ile Ser Ala Val Pro Ser Ile Glu Met Val Arg Phe
145 150 155 160

Val Asn Ser Gly Thr Glu Ala Cys Met Gly Ala Leu Arg Leu Val Arg
165 170 175

Ala Phe Thr Gly Arg Glu Lys Ile Ile Lys Phe Glu Gly Cys Tyr His
180 185 190

Gly His Ala Asp Ser Phe Leu Val Lys Ala Gly Ser Gly Val Ala Thr
195 200 205

Leu Gly Leu Pro Asp Ser Pro Gly Val Pro Lys Gly Ala Thr Tyr Glu
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CCDS: Oryza sativa

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gtgccttcaa	atcagttggg	gggcanccca	ttgtgtttga	ttctgtgaag	ggtctcgtat		300
gtgggagtgc	gatggaaatg	aatatatcga	ttangttggg	ntcctgangg	tcntnggatn		360
atcgggtgat	gcagatgata	cngttaatgc	agcatnattg	aacncaaaan	aaaganctnc		420
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Ile Ser Val Glu Lys Gly Glu Lys Ala Tyr Thr Val Glu Lys Ser Glu
      35                      40                      45

Glu Ile Phe Asn Ala Ala Lys Glu Leu Met Pro Xaa Gly Val Asn Ser
    50                      55                      60

Pro Val Arg Ala Phe Lys Ser Val Gly Gly Xaa Pro Ile Val Phe Xaa
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Phe Cys Glu Gly Ser Arg Met Trp Asp Val Asp Gly Asn Glu Tyr Ile
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Asp Xaa Val Gly
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gagaagtccg aggagatctt caacgccgcc aaggagtga tgcctggggg tgttaattca 240
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Arg Ala Pro Arg Ser Val Val Arg Ala Ala Ile Ser Val Glu Lys Gly
35 40 45
Glu Lys Ala Tyr Thr Val Glu Lys Ser Glu Glu Ile Phe Asn Ala Ala

Abstract

Val	Arg	Gly	Val	Leu	Asp	Ala	Gly	Ala	Lys	Thr	Gly	His	Glu	Met	Cys
385					390					395					400
Gly	Gly	His	Ile	Arg	Gly	Met	Phe	Gly	Phe	Phe	Phe	Thr	Ala	Gly	Pro
				405					410					415	
Val	His	Asn	Phe	Gly	Asp	Ala	Lys	Lys	Ser	Asp	Thr	Ala	Lys	Phe	Gly
			420					425					430		
Arg	Phe	Tyr	Arg	Gly	Met	Leu	Glu	Glu	Gly	Val	Tyr	Leu	Ala	Pro	Ser
		435					440					445			
Gln	Phe	Glu	Ala	Gly	Phe	Thr	Ser	Leu	Ala	His	Thr	Ser	Gln	Asp	Ile
	450					455					460				
Glu	Lys	Thr	Val	Glu	Ala	Ala	Ala	Lys	Val	Leu	Arg	Arg	Ile		
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Val Ser Ser Ala Ala Val Glu Leu Ala Leu Met Lys Leu Pro Glu Ala
260 265 270

Ser His Ala Asn Ala Arg Met Leu Val Ile Gly Ala Gly Lys Met Gly
275 280 285

Lys Leu Val Ile Lys His Leu Val Ala Lys Gly Cys Thr Lys Met Val
290 295 300

Val Val Asn Arg Ser Glu Glu Arg Val Ala Ala Ile Arg Glu Glu Ile
305 310 315 320

Lys Asp Val Glu Ile Ile Tyr Lys Pro Leu Ser Glu Met Leu Thr Cys
325 330 335

Ile Gly Glu Ala Asp Val Val Phe Thr Ser Thr Ala Ser Glu Asn Pro
340 345 350

Leu Phe Leu Lys Asp Asp Val Lys Glu Leu Pro Pro Ala Thr Asp Glu
355 360 365

Val Gly Gly Arg Arg Leu Phe Val Asp Ile Ser Val Pro Arg Asn Val
370 375 380

Gly Ser Cys Leu Ser Asp Leu Glu Ser Val Arg Val Tyr Asn Val Asp
385 390 395 400

Asp Leu Lys Glu Val Val Ala Ala Asn Lys Glu Asp Arg Leu Arg Lys
405 410 415

Ala Met Glu Ala Gln Ala Ile Ile Gly Glu Glu Ser Lys Gln Phe Glu
420 425 430

Ala Trp Arg Asp Ser Leu Glu Thr Val Pro Thr Ile Lys Lys Leu Arg
435 440 445

Ala Tyr Ala Glu Arg Ile Arg Leu Ala Glu Leu Glu Lys Cys Leu Gly
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Lys Met Gly Asp Asp Ile Asn Lys Lys Thr Gln Arg Ala Val Asp Asp
465 470 475 480

Leu Ser Arg Gly Ile Val Asn Lys Leu Leu His Gly Pro Met Gln His
485 490 495

Leu Arg Cys Asp Gly Ser Asp Ser Arg Thr Leu Ser Glu Thr Leu Glu
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Asn Met His Ala Leu Asn Arg Met Phe Asn Leu Glu Thr Glu Ile Ser
515 520 525

Val Leu Glu Gln Lys Ile Arg Ala Lys Val Glu Gln Lys Pro
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Arg	Ala	Ala 35	Val	Ser	Ile	Asp	Glu 40	Lys	Ala	Tyr	Thr	Val 45	Gln	Lys	Ser
Glu	Glu 50	Ile	Phe	Asn	Ala	Ala 55	Lys	Glu	Leu	Met	Pro 60	Gly	Gly	Val	Asn
Ser 65	Pro	Val	Arg	Ala	Phe 70	Lys	Ser	Val	Gly	Gly 75	Gln	Pro	Ile	Val	Phe 80
Asp	Ser	Val	Lys	Gly 85	Ser	His	Met	Trp	Asp 90	Val	Asp	Gly	Asn	Glu 95	Tyr
Ile	Asp	Tyr	Val 100	Gly	Ser	Trp	Gly	Pro 105	Ala	Ile	Ile	Gly	His 110	Ala	Asp
Asp	Lys	Val 115	Asn	Ala	Ala	Leu	Ile 120	Glu	Thr	Leu	Lys	Lys 125	Gly	Thr	Ser
Phe	Gly 130	Ala	Pro	Cys	Ala	Leu 135	Glu	Asn	Val	Leu	Ala 140	Gln	Met	Val	Ile
Ser 145	Ala	Val	Pro	Ser	Ile 150	Glu	Met	Val	Arg	Phe 155	Val	Asn	Ser	Gly	Thr 160
Glu	Ala	Cys	Met	Gly 165	Ala	Leu	Arg	Leu	Val 170	Arg	Ala	Phe	Thr	Gly 175	Arg
Glu	Lys	Ile	Leu 180	Lys	Phe	Glu	Gly	Cys 185	Tyr	His	Gly	His	Ala 190	Asp	Ser
Phe	Leu	Val 195	Lys	Ala	Gly	Ser	Gly 200	Val	Ala	Thr	Leu	Gly 205	Leu	Pro	Asp
Ser	Pro 210	Gly	Val	Pro	Lys	Gly 215	Ala	Thr	Val	Gly	Thr 220	Leu	Thr	Ala	Pro
Tyr 225	Asn	Asp	Ala	Asp	Ala 230	Val	Lys	Lys	Leu	Phe 235	Glu	Asp	Asn	Lys	Gly 240
Glu	Ile	Ala	Ala	Val 245	Phe	Leu	Glu	Pro	Val 250	Val	Gly	Asn	Ala	Gly 255	Phe
Ile	Pro	Pro	Gln 260	Pro	Ala	Phe	Leu	Asn 265	Ala	Leu	Arg	Glu	Val 270	Thr	Lys
Gln	Asp	Gly 275	Ala	Leu	Leu	Val	Phe 280	Asp	Glu	Val	Met	Thr 285	Gly	Phe	Arg
Leu	Ala 290	Tyr	Gly	Gly	Ala	Gln 295	Glu	Tyr	Phe	Gly	Ile 300	Thr	Pro	Asp	Val
Thr 305	Thr	Leu	Gly	Lys	Ile 310	Ile	Gly	Gly	Gly	Leu 315	Pro	Val	Gly	Ala	Tyr 320

Gly Gly Arg Lys Asp Ile Met Glu Met Val Ala Pro Ala Gly Pro Met
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 Tyr Gln Ala Gly Thr Leu Ser Gly Asn Pro Leu Ala Met Thr Ala Gly
 340 345 350
 Ile His Thr Leu Lys Arg Leu Met Glu Pro Gly Thr Tyr Glu Tyr Leu
 355 360 365
 Asp Lys Val Thr Gly Glu Leu Val Arg Gly Ile Leu Asp Val Gly Ala
 370 375 380
 Lys Thr Gly His Glu Met Cys Gly Gly His Ile Arg Gly Met Phe Gly
 385 390 395 400
 Phe Phe Phe Ala Gly Gly Pro Val His Asn Phe Asp Asp Ala Lys Lys
 405 410 415
 Ser Asp Thr Ala Lys Phe Gly Arg Phe His Arg Gly Met Leu Gly Glu
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 450 455 460
 Val Leu Arg Trp Ile
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